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*Tri-Service Site Characterization and Analysis Penetrometer System Program*

# **SCAPS Investigation of Chlorinated Volatile Organic Compounds in Groundwater at Building 525, Aberdeen Proving Ground, Maryland**

by *William M. Davis, Jeff F. Powell,  
S. Paul Miller, Stanley M. Swartzel*

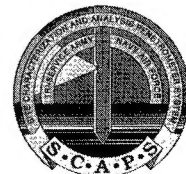
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ABSTRACT  
This report describes the results of a SCAPS investigation of chlorinated volatile organic compounds (CVOCs) in groundwater at Building 525, Aberdeen Proving Ground, Maryland. The investigation was conducted as part of the Tri-Service Site Characterization and Analysis Penetrometer System Program. The results of the investigation are presented in this report.

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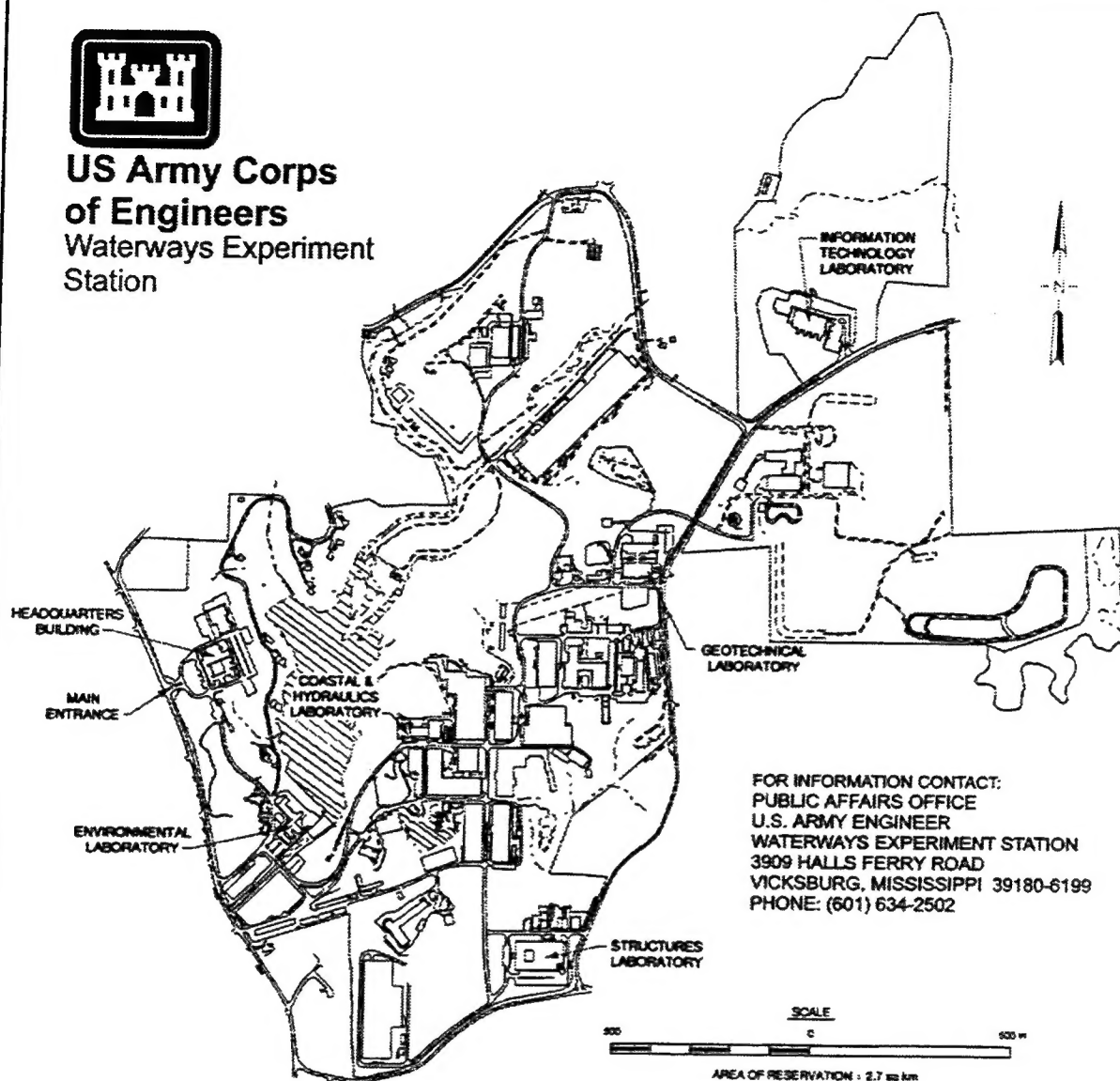
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# Preface

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This report was prepared by the Environmental Laboratory (EL) of the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS. The research was funded under the Tri-Service Site Characterization and Analysis Penetrometer System (SCAPS) Program by the U.S. Army Environmental Center (AEC). The Program is managed by Dr. John Cullinane, WES, and Mr. George Robitaille was the Technical Monitor for the AEC. Personnel who cooperated in the execution of the study and the preparation of this report include Dr. William M. Davis, Principal Investigator, Ecosystem Processes and Effects Branch (EPEB), Environmental Processes and Effects Division (EPED), and Mr. Karl F. Konecny, Environmental Engineering Division, EL; Mr. Jeff F. Powell, Instrumentation Services Division, Information Technology Laboratory (ITL); Mr. S. Paul Miller, Hydrogeology and Site Characterization Section, and Mr. Stanley M. Swartzel, Geologic Environments Analysis Section, Earthquake Engineering and Geophysics Division (GG), Geotechnical Laboratory (GL); and Mr. Donald Harris, Public Works Division, WES.

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# Conversion Factors, Non-SI to SI Units of Measurement

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Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
feet	0.3048	meters
inches	0.0254	meters
miles (U.S. statute)	1.609347	kilometers
tons (2,000 pounds, mass)	907.1847	kilograms



# 1 Introduction

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Aberdeen Proving Ground (APG) is a U.S. Army research test and evaluation center located approximately 20 miles<sup>1</sup> northeast of Baltimore, MD (Figure 1). Research and field testing of various vehicles and weapon systems have been conducted at APG since 1917. Building 525 at APG was constructed during World War II in the northeast portion of APG (Figure 2) and was used by the Aberdeen Test Center (ATC) to support testing. Activities in and around the building site such as cleaning, packaging, and painting of large gun barrels and military rolling stock have required use of large quantities of solvents and petroleum products.

In past times, a railroad track through Building 525 allowed artillery and other equipment to be brought into the building, unpacked, cleaned, and then transported to ranges. The equipment was returned to Building 525 for cleaning, painting, and repacking for transport off post. A contamination assessment report described solvent tanks located within Building 525 and discussed the use and disposal of the solvents (General Physics Corporation 1995). Practices at an abandoned wash rack at the east corner of Building 525 were also described.

In addition to activities in and around the building site and practices at the wash rack area, underground storage tanks (USTs) and sewers were identified as possible sources of contamination (Figure 3). An 18-in. concrete storm sewer and sanitary sewer lines run along the southeast side of the building. The storm sewer drains into Woodrest Creek approximately 250 ft from the southern corner of Building 525. Two USTs at the site were removed from service under the APG UST program. A fuel oil UST partially beneath the building was abandoned in place and filled with sand in November 1991. A 43-year-old solvent UST located approximately 100 ft from the building was removed along with 169 ft<sup>3</sup> of soil in November 1993. Although piping above the tank had deteriorated, integrity testing showed the tank was intact.

Because of soil contamination found during excavation of the solvent tank, APG contracted General Physics Corporation to conduct a preliminary contamination assessment (PCA) of the site (General Physics Corporation 1994).

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<sup>1</sup> A table of factors for converting non-SI units of measurement to SI units is presented on page vi.

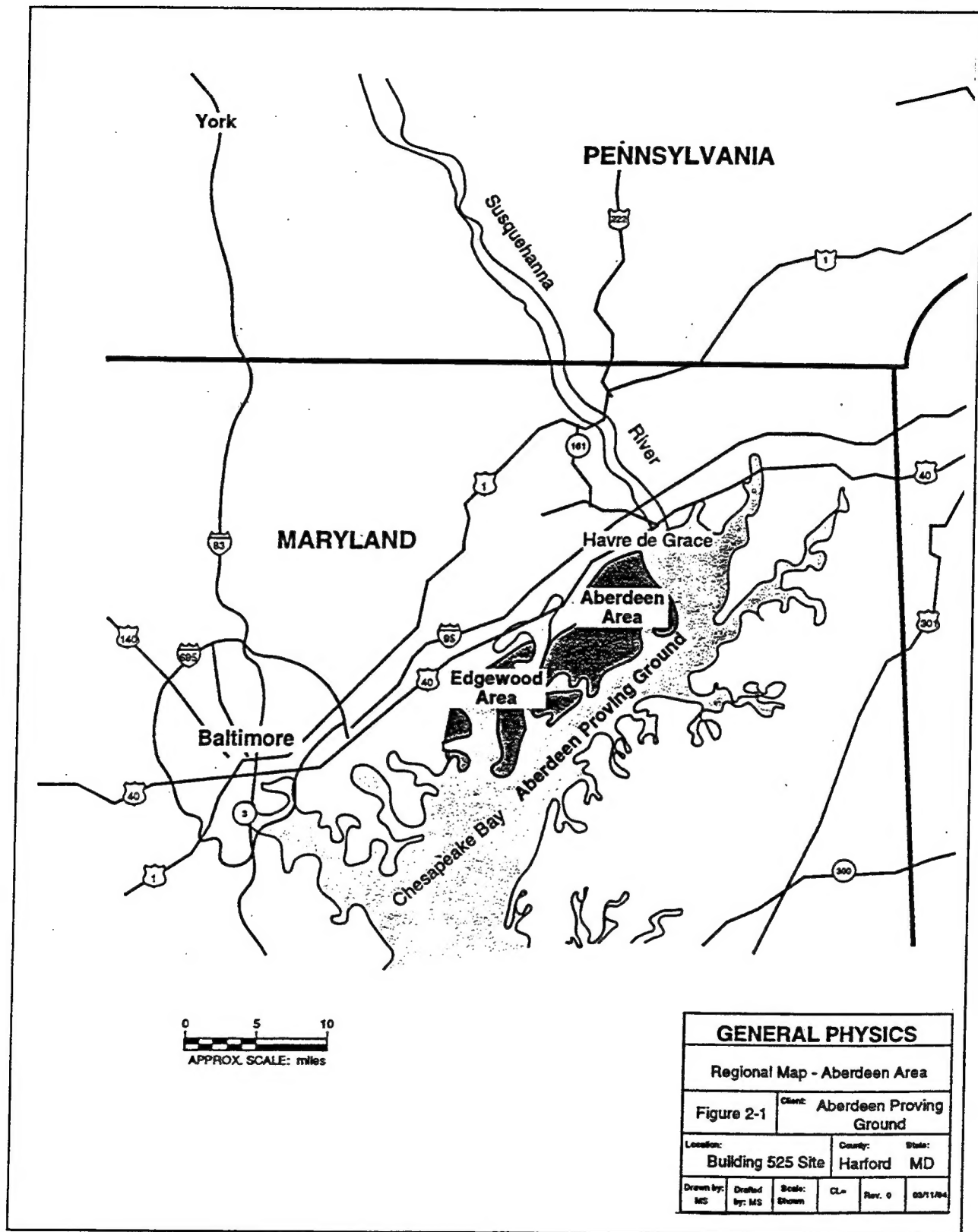


Figure 1. Map showing APG location

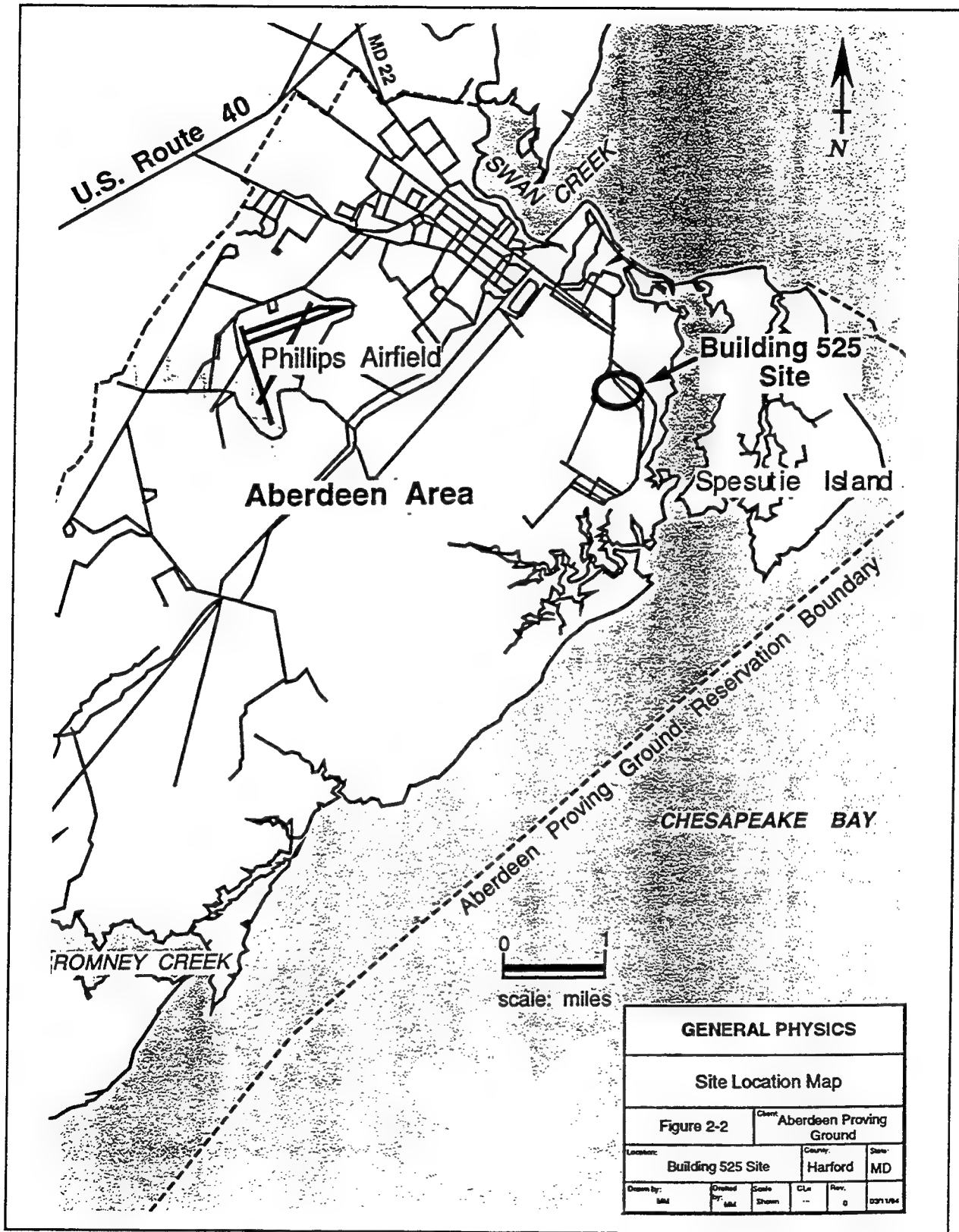


Figure 2. Map showing Building 525 site within APG

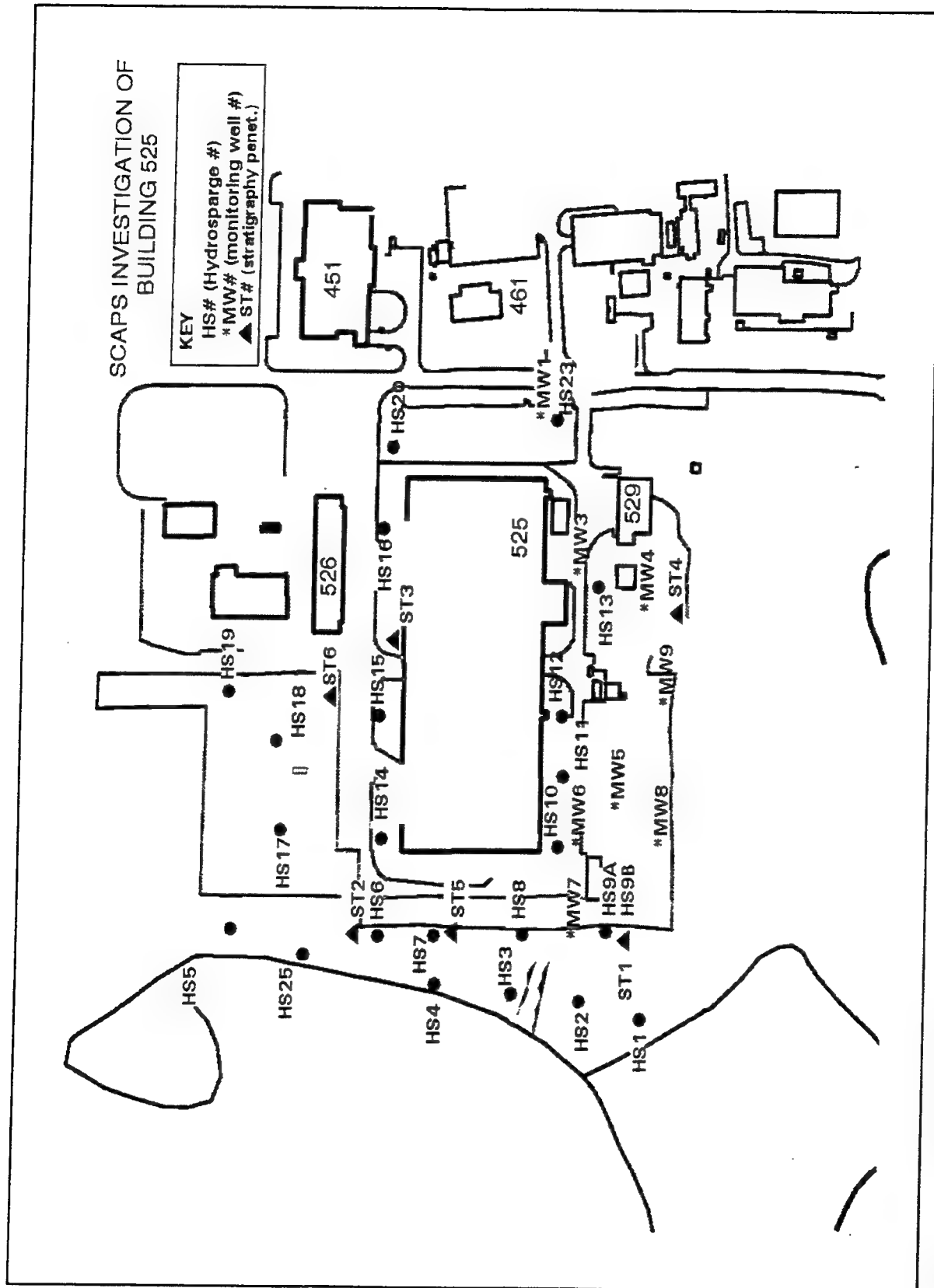


Figure 3. Diagram detailing Building 525 site

Using a Geoprobe sampling system, samples of soil were taken in 16 locations at three depths, and groundwater samples were taken from the water table in 22 locations along the southeastern side of Building 525. An onsite portable gas chromatograph (GC) was used to analyze all samples for benzene, toluene, ethylbenzene, and xylene (BTEX) and total volatile organic compounds (VOC). Additionally, groundwater laboratory analysis for VOC was conducted on all groundwater samples. The groundwater contained several chlorinated solvents such as 1,1,1-trichloroethane (TCA), trichloroethene (TCE), tetrachloroethene (PCE), and 1,1-dichloroethane (DCA).

Following the 1994 PCA, a more extensive investigation was conducted to further characterize site contamination (General Physics Corporation 1995). More Geoprobe sampling was conducted; five soil borings and 10 monitoring wells were made; and surface water and the wells were sampled. Chlorinated compounds were found in a shallow aquifer ranging in depth from 15 to 30 ft and in the surface water of Woodrest Creek. Only the areas east, southeast, and south of the building were examined. The report recommended further investigation of the Building 525 site, including deeper aquifers, surface waters, and sewers.

In May 1995, the U.S. Army Environmental Center (AEC) at APG coordinated a field demonstration/validation of the Site Characterization and Analysis Penetrometer System (SCAPS) at Building 525. The APG Directorate of Safety, Health, and Environment (DSHE) and the U.S. Army Engineer Waterways Experiment Station (WES) developed a plan to investigate subsurface VOC contamination at the Building 525 site using SCAPS. Personnel of AEC, DSHE, ATC, and WES designed a site characterization plan that would provide data both for validation of SCAPS sensors and for better geotechnical and contaminant definition of the site. This report details results of the SCAPS investigation.

## 2 Methods

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The SCAPS consists of the cone penetrometer truck, enclosed support trailer containing decontamination wash water and grout pumping systems, and a mobile analytical laboratory van (Figure 4). The SCAPS sensor and sampler systems used at the Building 525 site were the soil classification sensor, the Hydrosparge system, and the thermal desorption sampler. The penetrometer with its associated sensor and sampler systems is advanced into the soil using a hydraulic ram, with the SCAPS truck providing a 20-ton reaction mass. A digging clearance was obtained prior to performing any penetrations in compliance with APG regulations and the SCAPS APG Safety Plan.

The SCAPS soil classification sensor measures resistance to penetration and sleeve friction. Strain gauges mounted in the penetrometer cone tip and sleeve measure these forces and provide soil classification in accordance with procedures described in American Society for Testing and Materials (ASTM) Method D3441 (ASTM 1995). For a more detailed description of the SCAPS soil classification sensor, see Lee et al. 1993. Normal operating procedures include calibration of the soil classification sensor at the beginning of each investigation and calibration checks periodically during normal operations.

The Hydrosparge (HS) system consists of a Hydropunch (HP) temporary well, an in situ sparge (IS) device, and an ion-trap mass spectrometer (ITMS). The normal operating procedures for the Hydrosparge system of investigating groundwater contamination include first accessing the groundwater using the HP. The HP is a temporary well that can be screened for a maximum of 4 ft. The HP was pushed to the depth of interest and the push pipe was retracted, exposing the screen to the groundwater. The height of the water in the HP was monitored with a conductivity meter. The time and the depth to groundwater were recorded. The measurements at Building 525 were performed with the HP screen fully opened, with one exception.

When the water level was stable, the IS device was lowered into the well. The IS device was operated at the groundwater surface, but sampled the water 18 in. below the groundwater surface in the well. The sparge device purged the VOC analytes in situ from the groundwater using He gas and transferred the analytes to the surface via a Teflon transfer line. The operation of the HS is illustrated in Figure 5. The analyte stream was directly interfaced to the

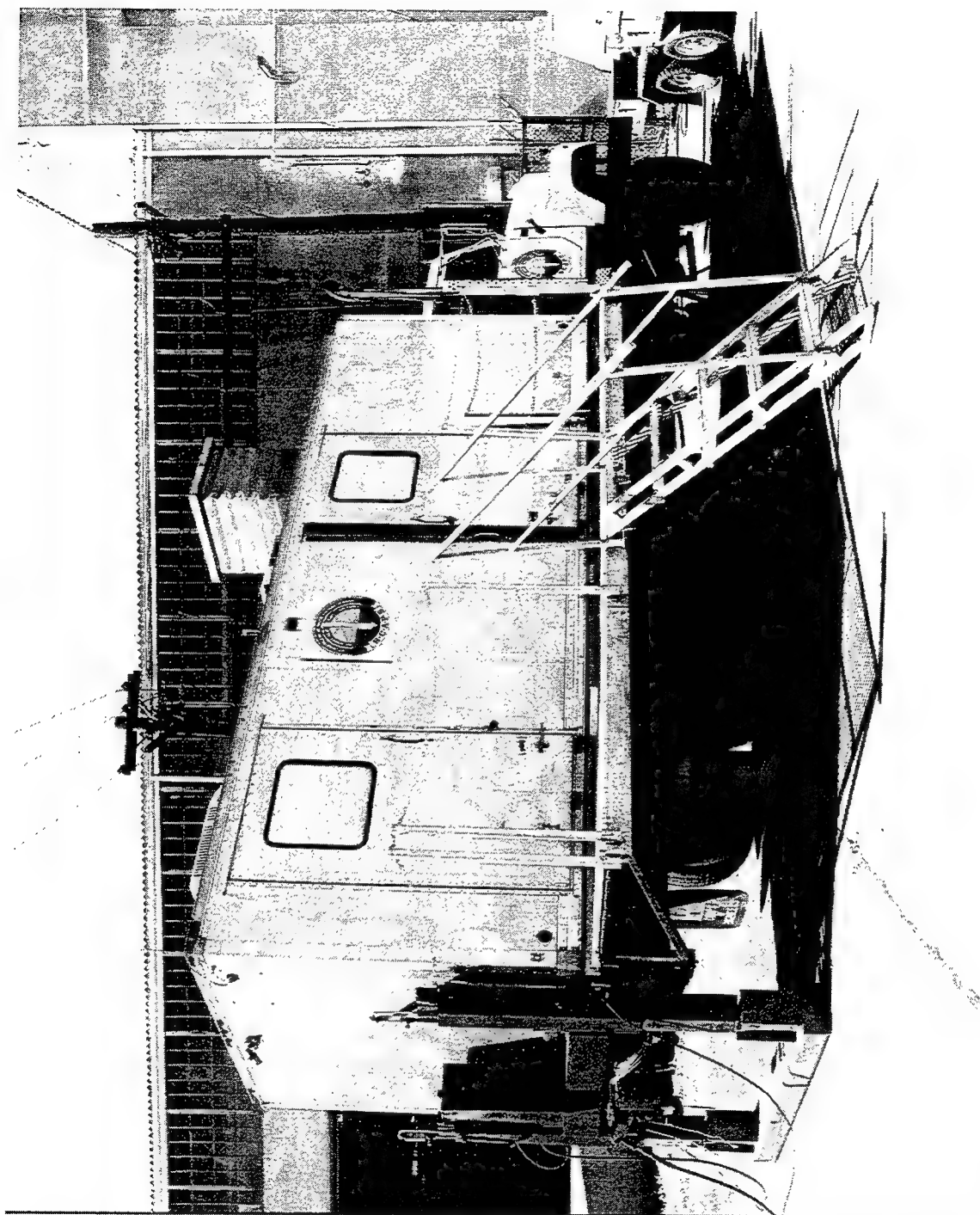


Figure 7. The SCAPS system

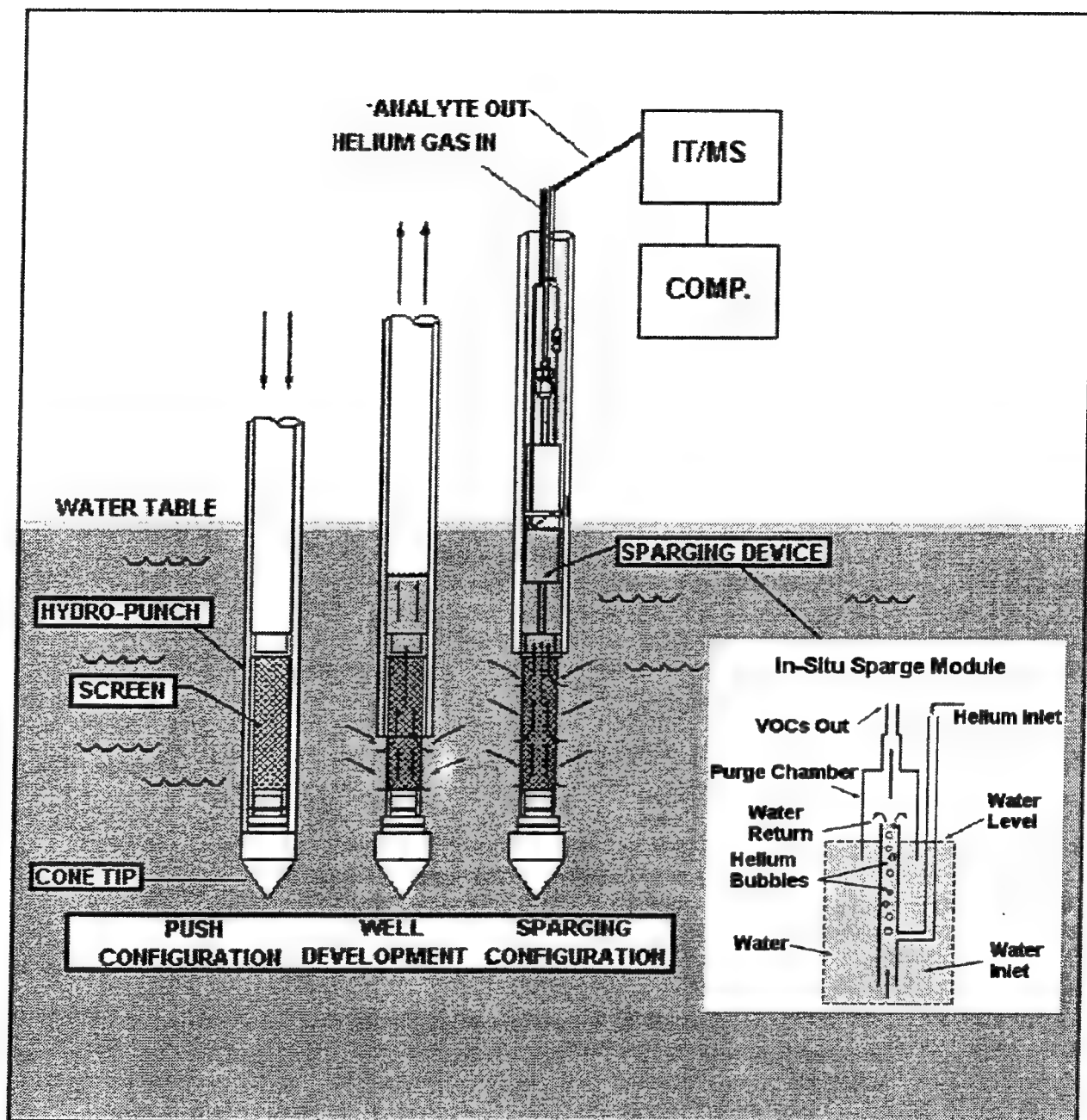


Figure 5. The Hydrosparge system



ITMS (Teledyne Electronics Technologies), and the VOC contaminants were analyzed.

The ITMS was operated in the full scan mode and data were acquired from the well for 4 to 5 min. The ITMS is capable of both qualitative identification of analytes based on their mass spectra and of quantitative measurement based on the intensities of analyte specific ions in the mass spectra. The Hydrosparge system was calibrated at the beginning of each deployment by spiking stock solutions of analytes into distilled water in a 250-mL flask. Blank samples and calibration standards were analyzed to create a calibration curve over a range of concentration (e.g., 5 to 500 µg/L). A calibration check standard and distilled water blank were analyzed before each HS investigation to confirm that the Hydrosparge system was within calibration and free of interferences.

Quantitation of the Hydrosparge data was performed by integrating intensities for characteristic masses for a fixed number of ITMS scans for each analyte. The integrated intensities for the calibrations were regressed against the analyte concentration to yield the calibration curves. The concentration of the analyte in the groundwater was calculated by integrating the same fixed number of scans for the characteristic masses from the data acquired during the Hydrosparge measurement and by using the regression equation from the calibration curve.

After completing the Hydrosparge measurement, a Teflon bailer equipped with a bottom-filling ball valve was used to sample groundwater for verification analysis. The bailer was gently lowered into the HP well and allowed to fill. The bailer was used to fill three 40-mL VOC vials (preserved with H<sub>2</sub>SO<sub>4</sub>) that were immediately placed on ice for storage until they were shipped for laboratory analysis. Samples were analyzed in the laboratory by U.S. Environmental Protection Agency (EPA) Method 8260 (EPA 1995). The data obtained from analysis of verification samples were compared with the results obtained with the Hydrosparge. After the IS/ITMS measurement and verification sampling were completed, the HP was retracted, leaving the tip and screen in place. The resulting penetration hole was immediately grouted to prevent downward migration of contaminants.

The HS investigations at the Building 525 site were performed from 14 August 1995 through 20 August. Surface water samples were obtained from Woodrest Creek near low tide on 23 August along a transect running in the creek from approximately 120 ft downstream to 120 ft upstream from the storm water drain. Twelve surface water locations were sampled by submerging 40-mL VOC vials and carefully sealing the filled vials with no headspace. The samples were analyzed in the SCAPS van using EPA Method 8265, which uses the ITMS with a vial sparge interface, and which was given provisional approval under EPA Methods for Analysis of Solid and Hazardous Waste.<sup>1</sup>

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<sup>1</sup> Personal Communication, 1996, B. Lesnik, Office of Solid Waste, U.S. Environmental Protection Agency, Washington, DC.

## 3 Results and Discussion

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### Site Stratigraphy

Previous investigations of the area adjacent to the south side of Building 525 consisted of Geoprobe penetrations to sample soil and/or groundwater, five soil borings for geophysical characterization, and 10 groundwater monitoring wells (General Physics Corporation 1995). These investigations indicated surficial fill in some areas, followed by clay, silt, and silt/clay mixes to a depth of 10 to 15 ft below ground surface (BGS). Below that depth, the boring logs indicated sand and sand/gravel mixes with narrow interbedded clay and silt/clay lenses to 25 to 30 ft BGS (see Figures 5-1, 5-2, and 5-3 in General Physics Corporation 1995). The depth to groundwater for the surficial aquifer was generally observed to be 12 to 15 ft BGS, and that aquifer was assumed to be unconfined.

All the soil borings and monitoring wells were terminated between 25 and 30 ft BGS except for SB01. This boring was located at the southeast corner of Building 525 and was performed to a depth of 71.5 ft. This boring indicated sand from 9.7 to 24.5 ft BGS, then clay to 26.5 ft BGS, and then sand (including gravelly sands and silty fine sands) to 57 ft BGS. Two narrow bands of clay were found at 57.2 to 58.3 ft BGS and 60 to 60.5 ft BGS. The interval from 66 to 70 ft BGS was reported to be clay, with sandy clay observed to 71.5 ft BGS. Since only one boring was performed to a depth below 30 ft, the lower confining layer for the surficial aquifer was not well defined. Some of the soil borings and monitoring wells indicated a corresponding clay layer above 30 ft BGS (SB01, SB02, MW03, MW05, MW06), while others did not (SB4, MW08, and MW10).

A number of SCAPS stratigraphic penetrations were executed to address the lack of data at depths greater than 30 ft BGS. Initial plans called for five SCAPS stratigraphic penetrations to be performed in areas south, west, and north of the building, with additional penetrations performed as time permitted. The penetrations were planned to investigate subsurface stratigraphy to 100 ft BGS where possible. The stratigraphic penetrations west and north of Building 525 were planned to provide geologic data in areas of the site not previously investigated.

Six stratigraphic penetrations were performed during the 2 working days (12 and 13 August 1995) allotted to investigate the subsurface site geology. There were two penetrations south and east of the building (ST01 and ST04, see Figure 3), one southwest of the building (ST05), and three west and north of the building (ST02, ST03, and ST06). The stratigraphic penetrations performed on the south side of Building 525 were near borings for the previous investigations. ST04 was performed near the previous soil boring SB04, and ST05 was performed near previous monitoring well MW07. SCAPS penetration ST04 was pushed to 99 ft BGS, while SB04 went to 29 ft BGS; and ST05 went to 55 ft BGS, while MW07 went to 30 ft BGS. There were no previous subsurface investigations near the other SCAPS stratigraphic penetrations.

Data obtained from ST04 and ST05 indicated subsurface geology quite similar to that obtained from SB04 and MW07, respectively. The SCAPS data obtained for ST04 (Figure A4 in Appendix A) indicated sand/silt and silt/clay mixes from the surface to 9.5 ft BGS. The boring log for SB04 (Figure SB04, Appendix E, in General Physics Corporation 1995) indicated silt, clay, and sand over this interval. The SCAPS data from 9.5 to 21 ft BGS indicated sand mixes with two narrow (1 ft each) bands of silt. The log for SB04 recorded sand from 13 to 20.5 ft BGS. Both the SCAPS and soil boring data indicated a narrow clay band at approximately 20.5 ft BGS. The SCAPS data indicated sand mixes to 30 ft BGS where a band of silt and silt/clay begins. SB04 indicated sand from 21.5 to 28 ft BGS, then silt/clay to 29.5 ft BGS. Comparison of the data for ST05 (Figure A5) and the nearby MW07 (Figure MW07, Appendix E, in General Physics Corporation 1995) revealed that quite similar subsurface geology was determined by these two quite different methods.

Analysis of the stratigraphic data indicated the possibility of three aquifers between the ground surface and depths of 100 ft. The surficial aquifer generally begins below 10 ft BGS and extends to approximately 30 ft BGS. The second aquifer begins below 30 ft BGS and generally extends to approximately 50 ft BGS. It should be noted that the thickness of the clay layer beginning at approximately 30 ft BGS varies greatly over the site, and the second aquifer suggested here may actually be connected to the first. A clay layer (4 to 5 ft thick) was detected at approximately 50 ft BGS, and below this an interval of approximately 30 ft of sand was detected (Figures A1 and A4). The clay layer below this sand appeared to be at least 20 ft thick, suggesting a well-confined third aquifer.

The data produced by the SCAPS stratigraphic sensor can be used to produce a three-dimensional (3-D) visualization of the subsurface geology at any particular site (Lee et al. 1994; Davis et al. 1997). The large area and low density of penetrations at the Building 525 site reduced the usefulness of such a visualization. However, the 3-D visualization (Figure 6) produced for the six stratigraphic penetrations performed at this site is informative. Since the SCAPS stratigraphic data were similar to the previous soil boring and monitoring well stratigraphic data as discussed above, the two data sets were

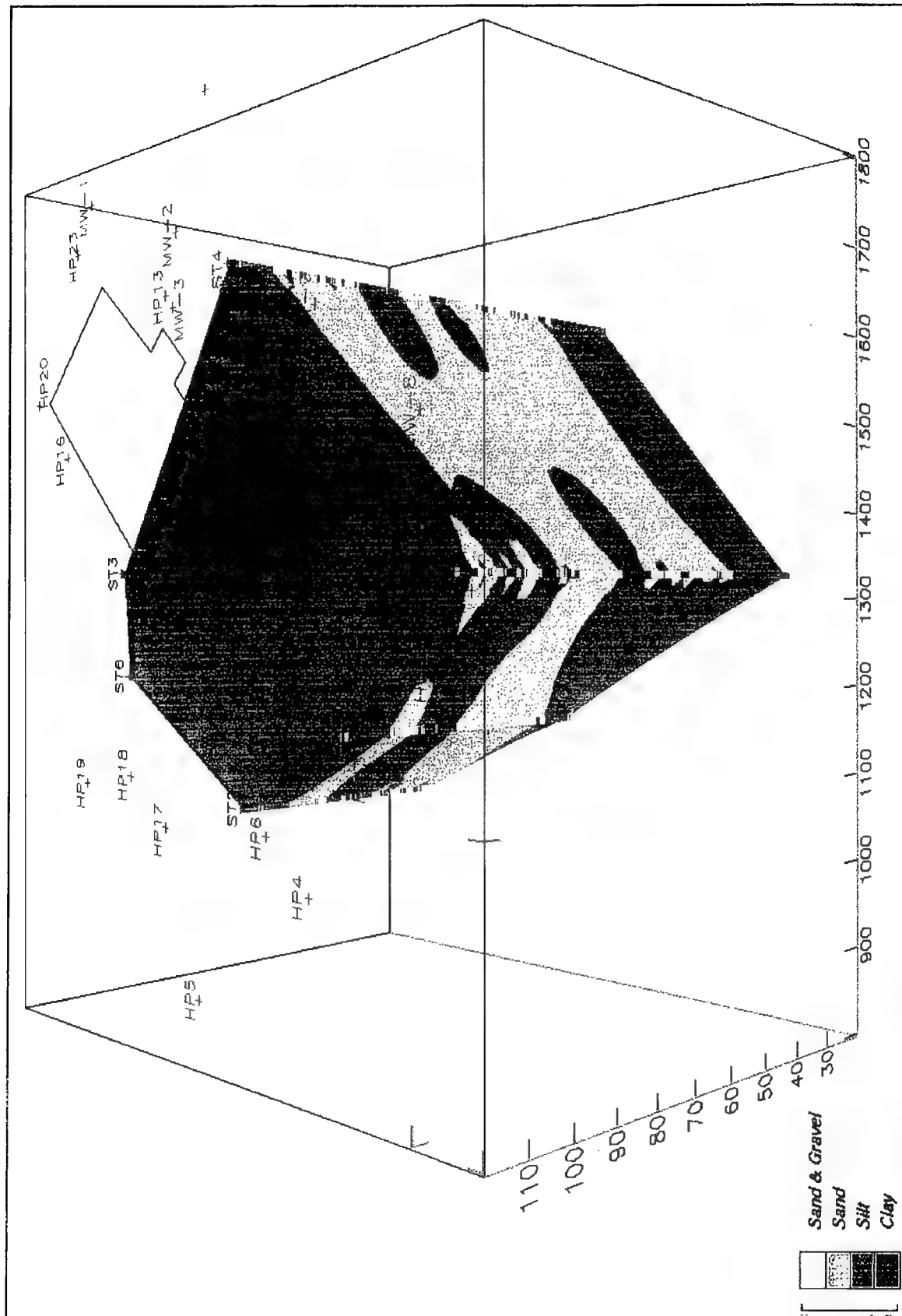


Figure 6. View of SCAPS stratigraphic data

combined. The soil boring and monitoring well data were converted to equivalent SCAPS stratigraphic data. These data were then combined with the SCAPS data to produce a 3-D visualization of the entire site stratigraphy (Figure 7).

## Hydrosparge Investigations

Previous investigations of soil and groundwater contamination on the south side of Building 525 consisted of approximately 40 Geoprobe borings for soil and groundwater sampling and the installation of 10 monitoring wells for groundwater sampling (General Physics Corporation 1995). Results of laboratory analyses from these investigations indicated chlorinated organic compounds in soil and groundwater. The chlorinated VOC contaminants in this area were TCA, TCE, and their breakdown products. Suspected sources of the contaminants in this area were a wash rack near the southeast end of the building and a recently removed solvent UST west of Building 525 (Figure 3).

The previous investigations indicated that the VOC contaminants in the surficial aquifer were migrating toward Woodrest Creek on the west side of the site (General Physics Corporation 1995). Study of contamination patterns on the southwest side of the building suggested that additional VOC sources could exist northwest of the building. Previous investigations recommended that additional characterizations of the surficial aquifer on the northwest side of Building 525 and of deeper aquifers were needed. Based on those recommendations, 25 locations were identified on all sides of Building 525 for groundwater investigation (Figure 3) using the SCAPS Hydrosparge. The numeric labels of HP locations do not represent any special order.

The Hydrosparge groundwater investigations performed north and west of Building 525 detected no VOC contamination at the north end of the building (HS16 and HS20 - see Table 1). Significant VOC contamination was detected west of the building and in the vehicle parking area (HS14, HS17, and HS18). The source of the contamination in the west area of the Building 525 site appeared to be different from that affecting the southeast area, based on the ratios of concentrations of TCA to TCE. The ratios for southeast HP locations were mostly equal (and greater than one) despite the wide range of concentrations, while the contamination for west locations was predominantly TCE with much less TCA. Since the west locations with the most TCE were HS17 and HS18, the source of the TCE contamination in the northwest area was probably near HS17 and HS18.

The HS experiments performed on the southeast side of Building 525 yielded TCA and TCE groundwater concentrations similar to the results obtained in the previous investigations. For example, HS11 detected 270 µg/L TCA and 176 µg/L TCE, while MW05, the closest well, detected 257 µg/L TCA and 199 µg/L TCE (Table 5-4, General Physics Corporation 1995). The HP wells were generally screened from 10 to 22 ft BGS in this area, and the screen intervals for the monitoring wells near HS locations always bracketed

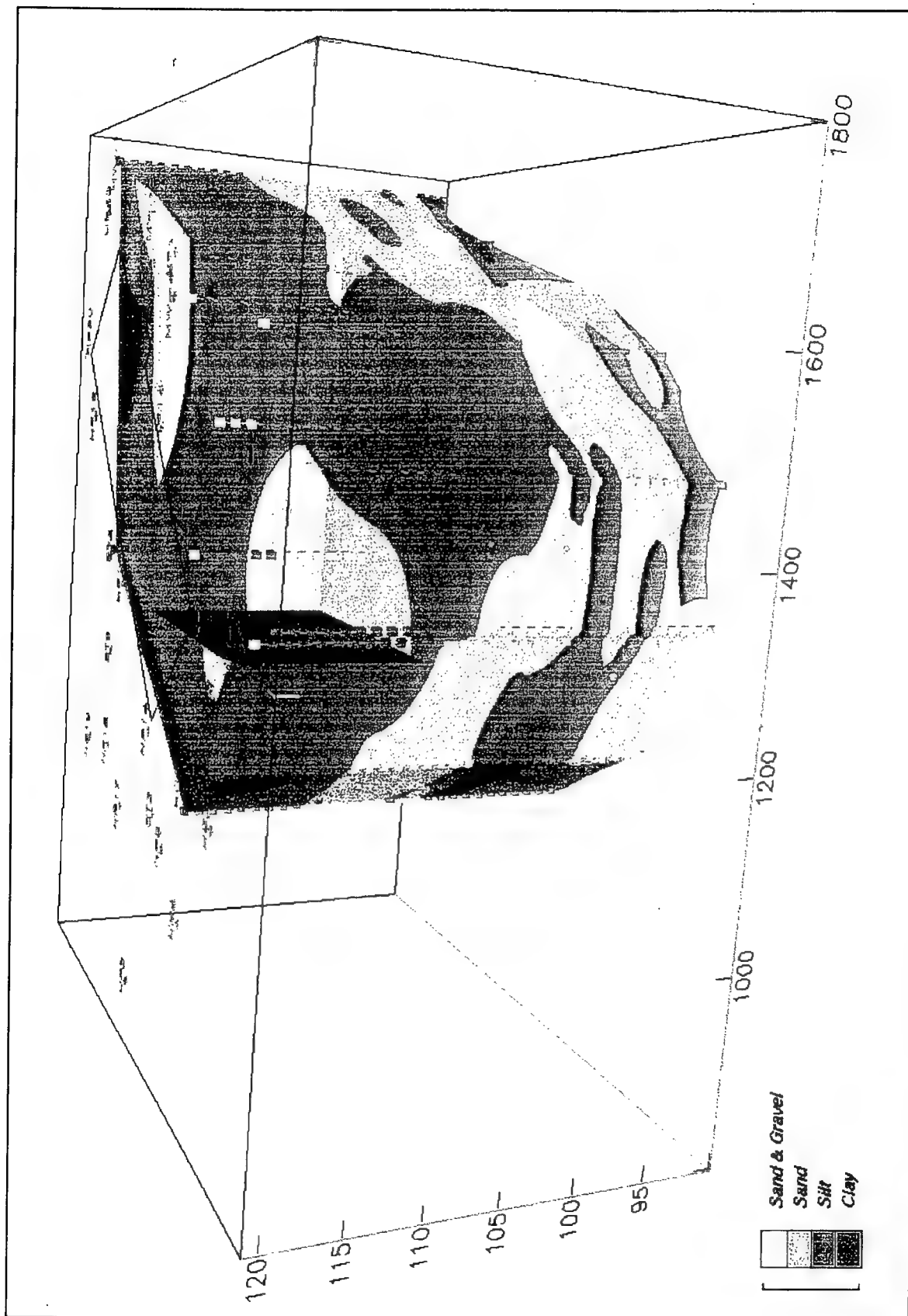


Figure 7. View of entire site stratigraphy

**Table 1**  
**SCAPS Hydrosparge Investigation Data From APG, 14-20 August 1995**

Sample Name	Hydrosparge TCA, ng/mL	EPA 8260 TCA, ng/mL	Hydrosparge TCE, ng/mL	EPA 8260 TCE, ng/mL	Screen ft BGS	Water Table ft BGS	Date
HS01	51	61	5	19	16-12	10	15/8
HS02	254	200	111	140	14-10.8	7.3	15/8
HS03	155	32	121	160	15-11	10.2	17/8
HS04	17	<5	10	<5	15-11	8.4	16/8
HS05	15	21	<5	7.7	15-11	4.9	16/8
HS06	<5	12	180	220	20-16	17	16/8
HS07	14	31	172	420	20-16	16.5	16/8
HS08	219	240	120	200	21-17	17.2	15/8
HS09A	<5	<5	<5	<5	70-66	19	14/8
HS09B	<5	<5	<5	12	45-41	18	15/8
HS10	685	510	398	450	22-18	17.3	20/8
HS11	270	170	176	180	22-18	16.9	20/8
HS12	1,462	1,300	942	1,200	22-18	16.2	19/8
HS13	13	24	<5	<5	22-18	15.9	19/8
HS14	18	19	172	250	20-16	17.5	17/8
HS15	16	13	27	30	20-16	16.6	17/8
HS16	<5	<5	<5	<5	22-18	15.4	18/8
HS17	100	66	607	570	20-16	17.2	19/8
HS18	68	88	602	870	21-17	17.8	18/8
HS19	12	18	9	24	20-16	17	18/8
HS20	<5	<5	<5	<5	22-18	14.6	18/8
HS23	6	<5	59	<5	21.8-17.8	15.2	19/8
HS25	<5	<5	34	<5	15-11	4.5	19/8

the HS screen intervals. However, the HS measurements near MW06 were not in agreement with the TCA and TCE concentrations obtained previously for MW06. This monitoring well was between HS10 to the west and HS11 to the east, which both indicated significantly higher concentrations of VOC. MW06 indicated the presence of 11 µg/L TCA and 33 µg/L TCE, while the average of HS10 and HS11 was approximately 500 µg/L TCA and 300 µg/L TCE.

HS12 (located slightly farther east from HS11) detected the highest VOC concentrations in groundwater at this site: these concentrations were

1,462 µg/L TCA and 942 µg/L TCE. These data were very similar to the contaminant levels detected previously at MW03, located much farther east along the side of Building 525. MW06, HS10, HS11, and HS12 provided the only data currently available for the area at the south corner of Building 525. The HS data obtained near MW06 indicated that there may be multiple sources or that a source near MW03 may extend westward to HS12.

VOC contamination of the two deeper aquifers was investigated by performing two different Hydrosparge measurements at location HP09. The first HS penetration at HS09 (HS09A) was performed to 70 ft BGS, and the well was screened from 70 to 66 ft BGS. The second penetration (HS09B) was laterally offset by just 2 ft from the first. It was performed to 45 ft BGS, and the well was screened from 45 to 41 ft BGS. Results of analyses indicated that neither penetration encountered chlorinated VOC contaminants above a threshold concentration of 5 µg/L (Table 1). However, the analysis of the bailed water sample from HS09B indicated the presence of TCE at 12 µg/L. One possible explanation is found from a more detailed consideration of the grouting procedure.

The HS penetrations were grouted after the HP tool was removed from the penetration hole. However, as the HP was retracted, flush mount 3/4-in.-ID polyvinyl chloride (PVC) pipe was lowered through the penetrometer push pipe and left in the penetration hole. Once the HP tool and push pipe had been retracted, the penetration hole was grouted using the inserted PVC pipe as a trimmie pipe. However, since the outer diameter of the HP is 2 in., there was an annular space available for possible cross contamination during the HP retraction before grouting was completed. Since HS09B was performed after HS09A, and HS08 and HS10 both indicated significant TCE contamination in the surficial aquifer (Table 1), the TCE observed in the bailed water sample obtained at HS09B may have been from a small amount of leakage during grouting of HS09A.

## Surface Water Investigation of Woodrest Creek

In addition to the HS investigations at this site, the potential impact of the surficial groundwater contamination on Woodrest Creek was investigated. Twelve surface water samples were obtained from a transect running upstream and downstream from the storm sewer drain near the southwest corner of Building 525 (Figure 8). Samples were obtained in duplicate and analyzed onsite for TCA and TCE. Samples were taken near low tide on 23 August 1995 beginning at a location about 120 ft downstream from the storm drain and extending to about 120 ft upstream. The total time taken for collection and analysis of all the surface water samples was under 3 hr.

The duplicated surface water sample analyses agreed on the presence of TCA and TCE in Woodrest Creek (Table 2). Streams of groundwater were observed to be flowing into Woodrest Creek near samples C3 and C5. The



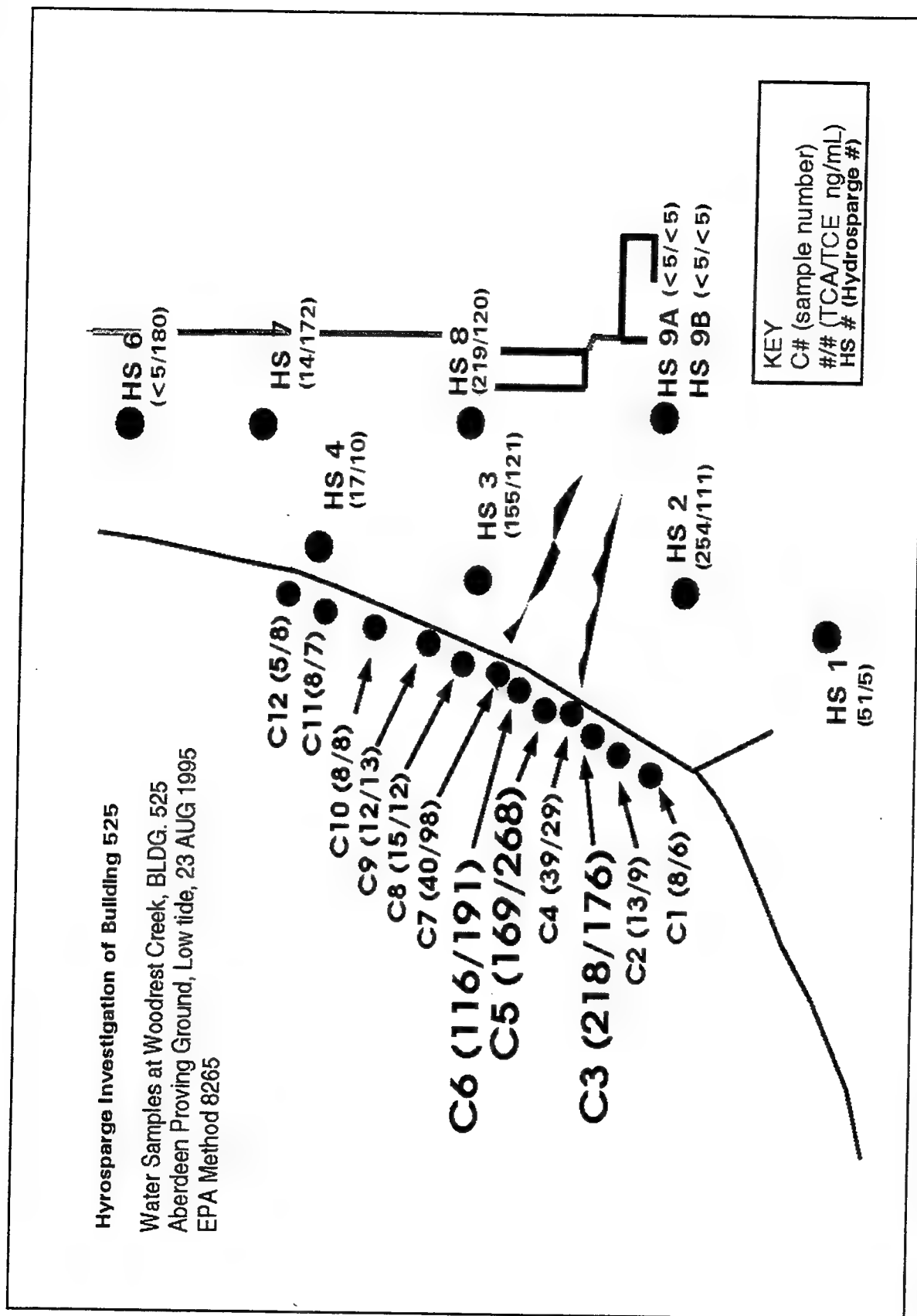


Figure 8. Surface water sampling locations

**Table 2**  
**Surface Water Data from Woodrest Creek Samples, Low Tide 23**  
**August 1995**

Sample Name	EPA 8265 TCA, ng/mL	EPA 8265 TCE, ng/mL
C1	8	6
C2	13	9
C3	218	176
C4	39	29
C5	169	268
C6	116	191
C7	40	98
C8	15	12
C9	12	13
C10	8	8
C11	8	7
C12	5	8

C3, C5, and C6 sampling locations are downgradient from the locations of HS02 and HS03, and the contaminant concentrations in the groundwater at those locations (Table 1) are similar to those obtained for the corresponding surface water sample locations (Table 2).

## Validation of Hydrosparge Results

Standard operation procedures for Hydrosparge investigations currently include validation sampling of the groundwater for each HS penetration. The samples are analyzed using EPA Method 8260, which is a purge and trap/GC/mass spectrometer method for quantifying VOC analytes in various matrices, including water. The samples were obtained with a 1.9-cm-ID Teflon bailer approximately 30 min after each Hydrosparge investigation was completed. Samples were stored on ice and shipped to the WES Analytical Laboratory Group for analysis.

The analytical results for VOC concentrations in the validation samples are given in Table 1 and are very similar to the results of corresponding Hydrosparge investigations. The laboratory data indicate that there are strong correlations between the Hydrosparge method and EPA Method 8260 for both TCA and TCE (Figure 9). Further, the slopes for both analytes are near one, indicating that both methods produce essentially identical results over a dynamic range of three orders of magnitude.

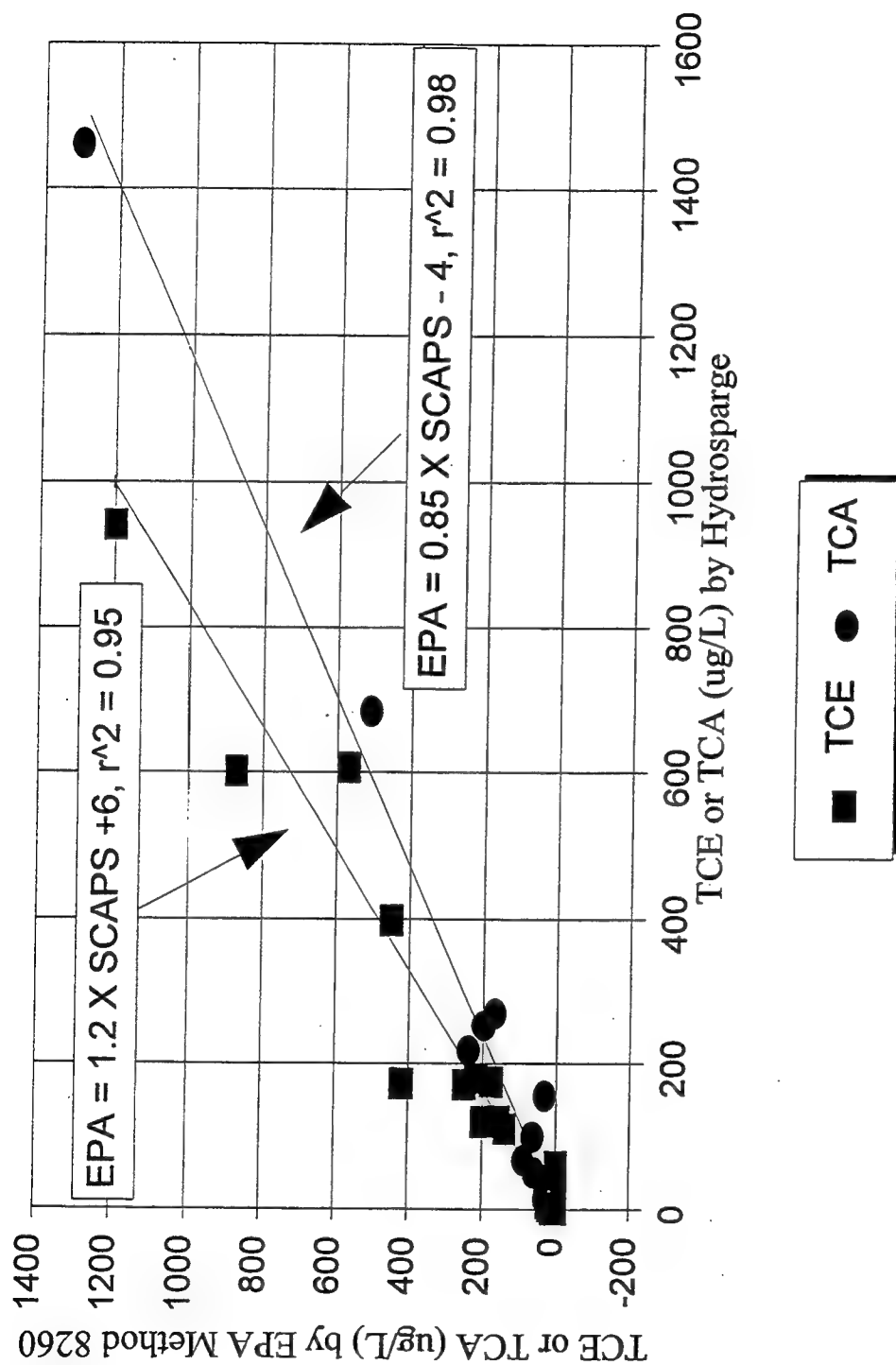


Figure 9. Comparison of validation and Hydrosparge data

## 4 Summary and Conclusion

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The Hydrosparge investigations performed at the Building 525 site confirmed the presence of TCA and TCE in the surficial groundwater southeast of the building. The results of HS10, HS11, and HS12 indicate that the source near MW03 may be larger and extend farther to the west than previously indicated. The surficial groundwater contamination does not appear to have migrated to deeper aquifers in this area.

The Hydrosparge investigations northwest of the building indicated another source of TCE contaminating the surficial groundwater near the west corner of the building. The contaminated surficial groundwater appears to be impacting Woodrest Creek in the vicinity of the storm sewer drain.

# References

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# **Appendix A**

## **SCAPS Sensor Panel Plots**

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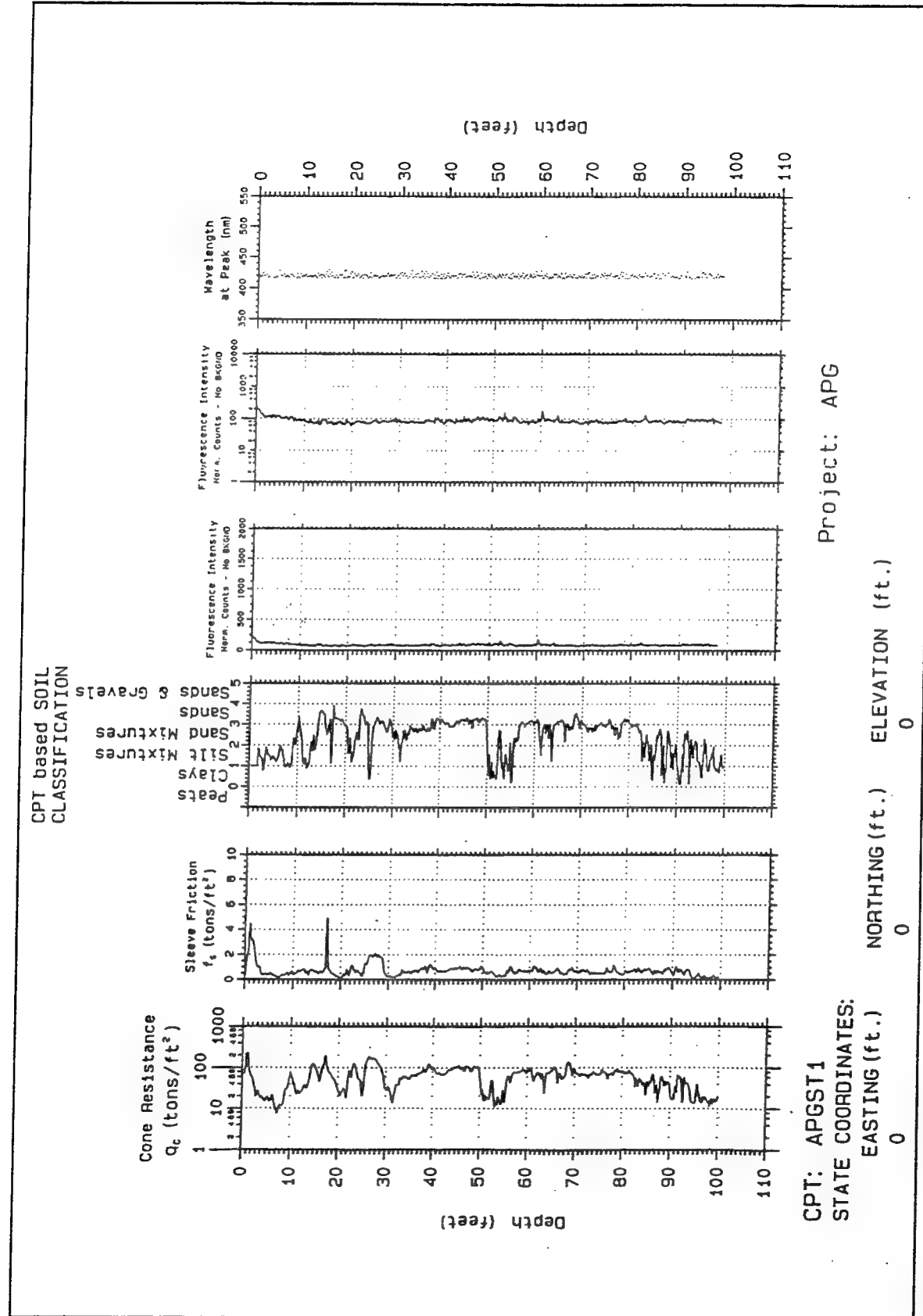


Figure A1. Stratigraphy CPT APGST 1 at Building 525, Aberdeen Proving Ground

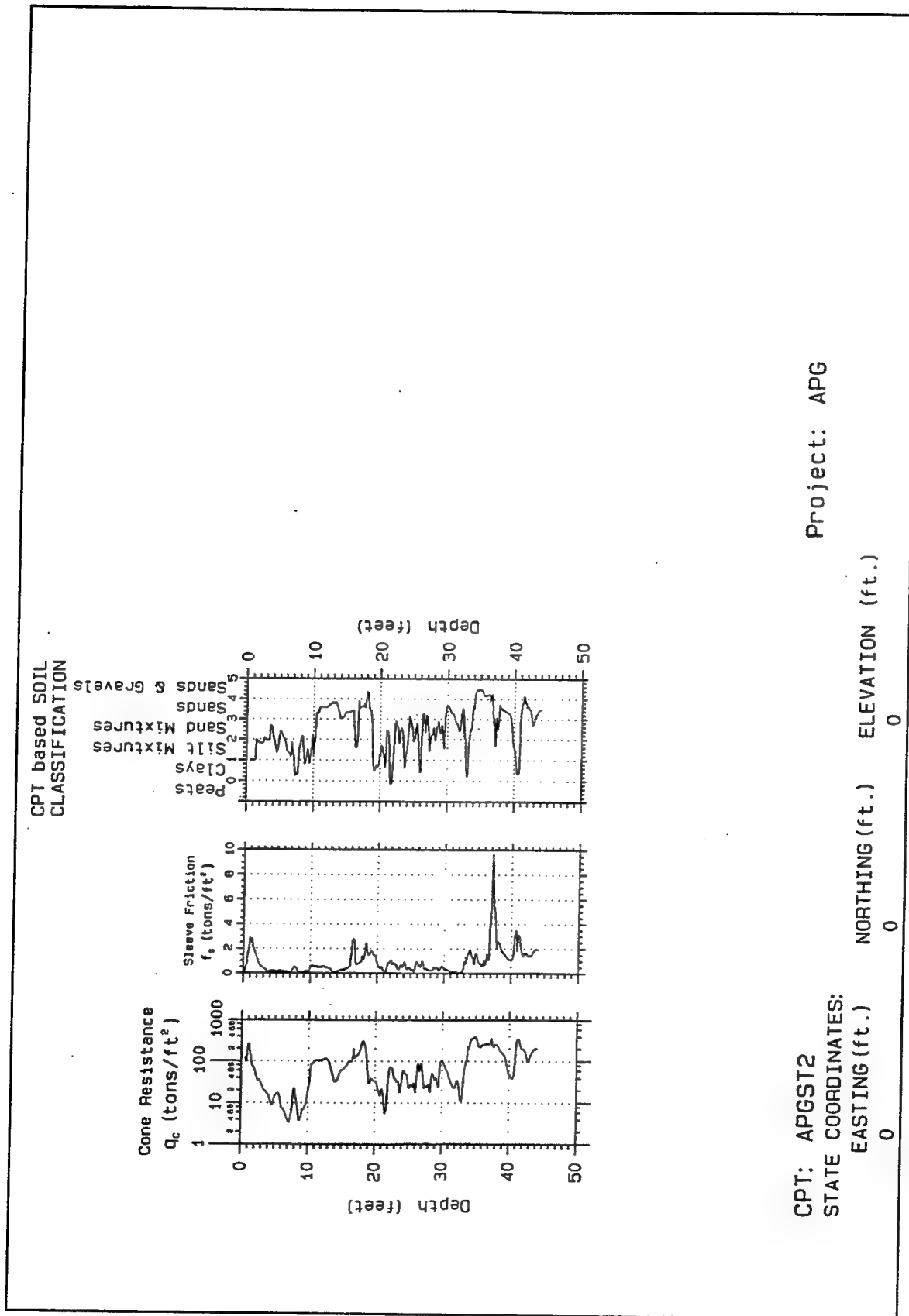


Figure A2. Stratigraphy CPT APGST 2 at Building 525, Aberdeen Proving Ground



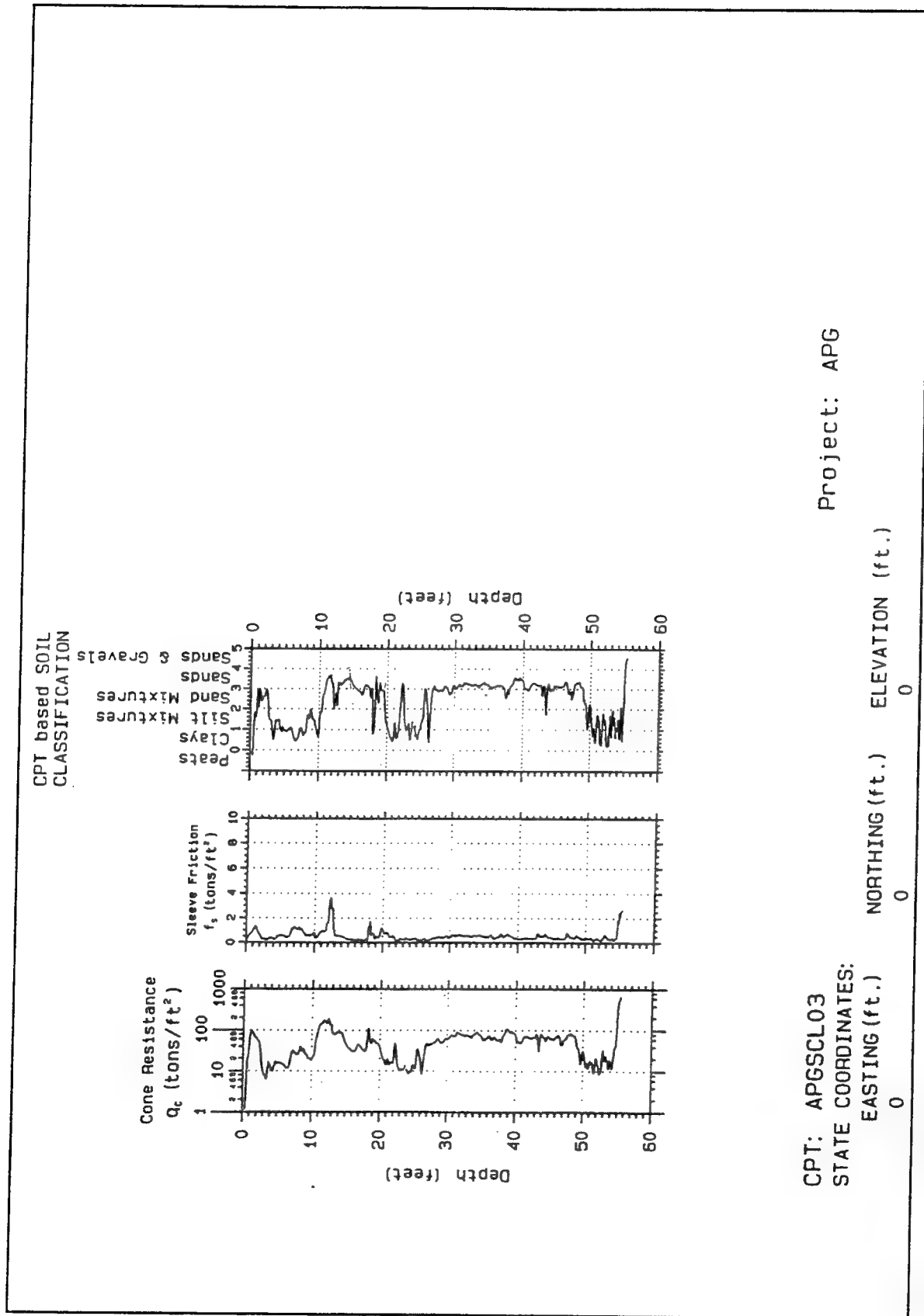


Figure A3. Stratigraphy CPT APGST 3 at Building 525, Aberdeen Proving Ground

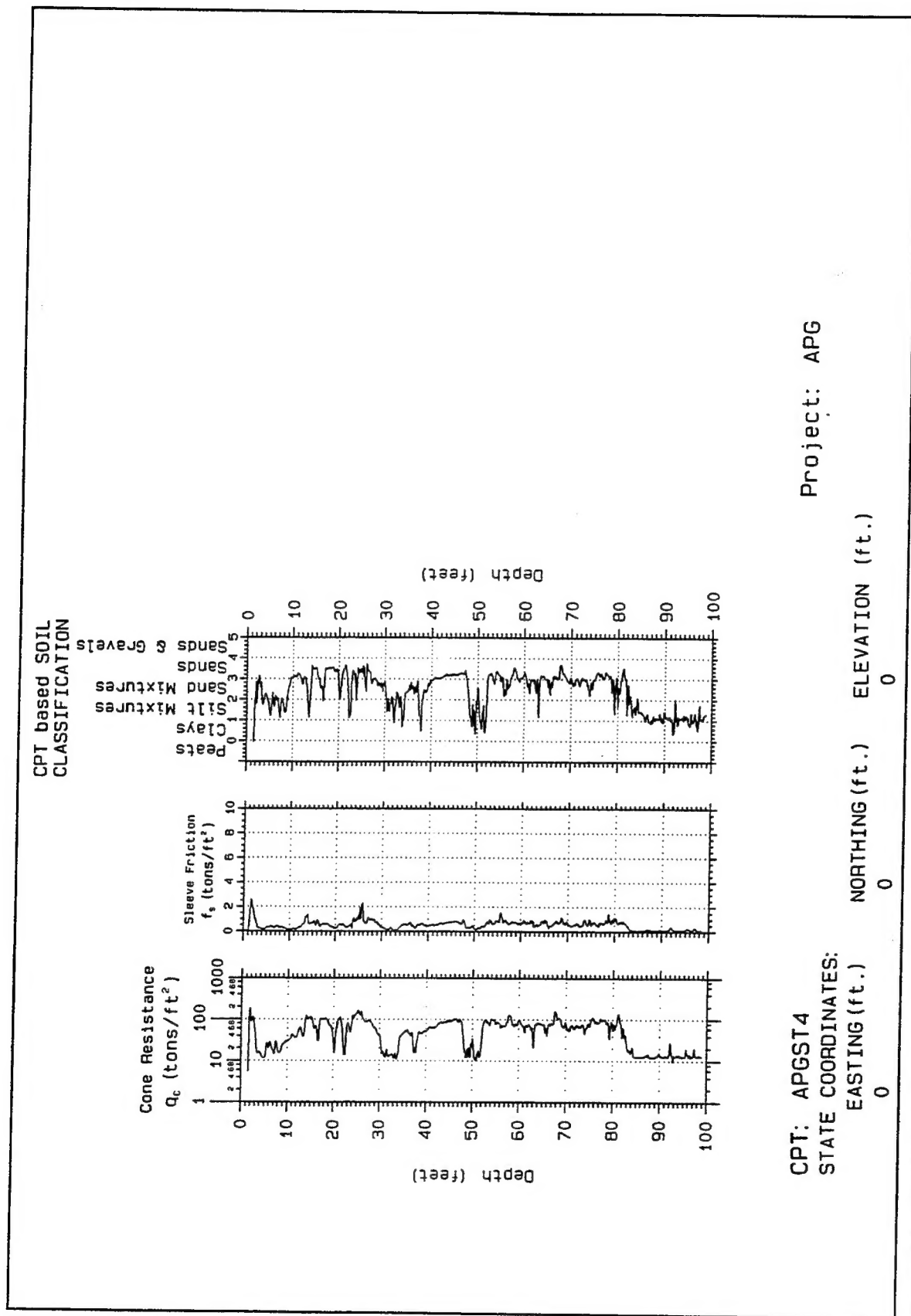


Figure A4. Stratigraphy CPT APGST 4 at Building 525, Aberdeen Proving Ground

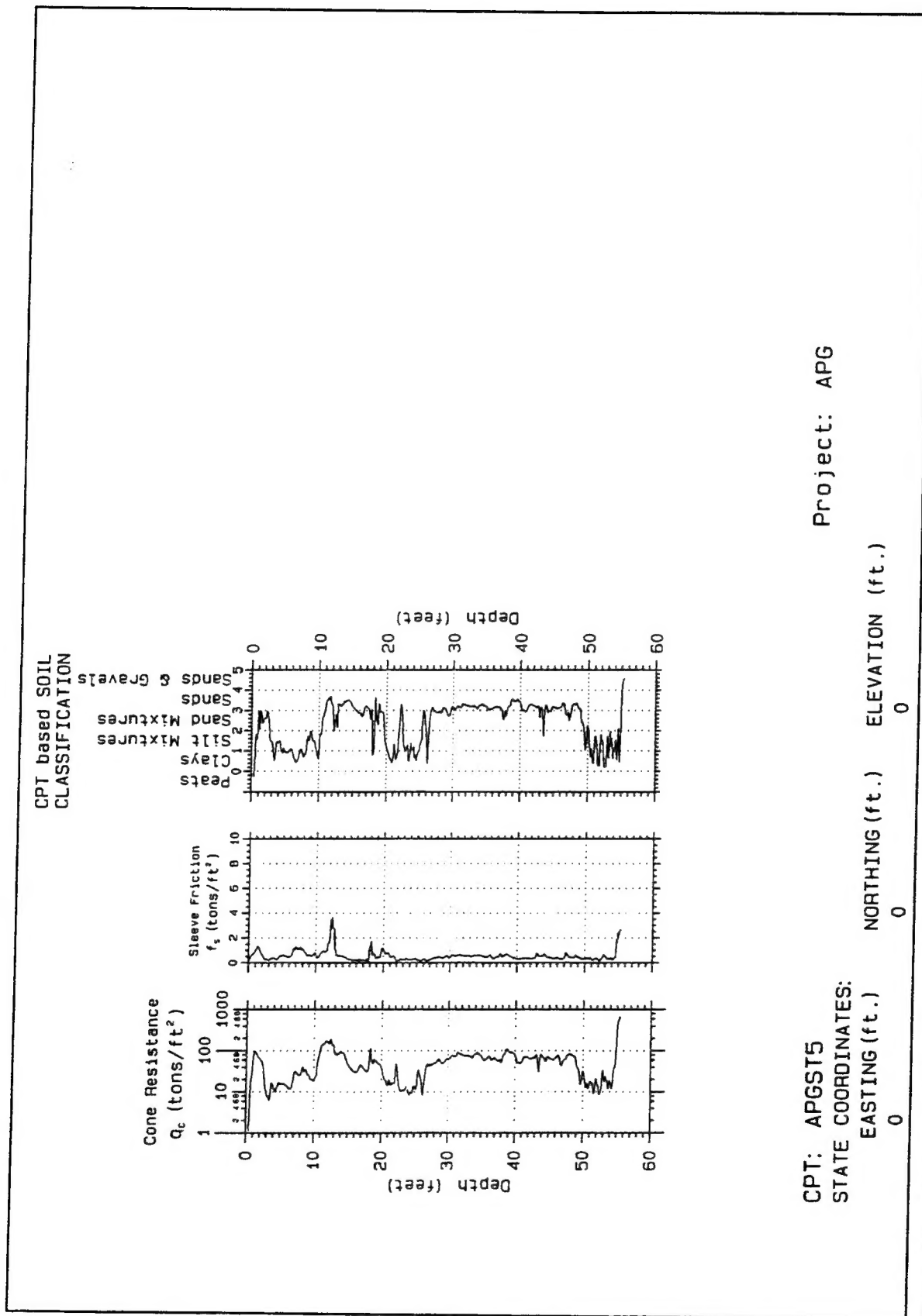


Figure A5. Stratigraphy CPT APGST 5 at Building 525, Aberdeen Proving Ground

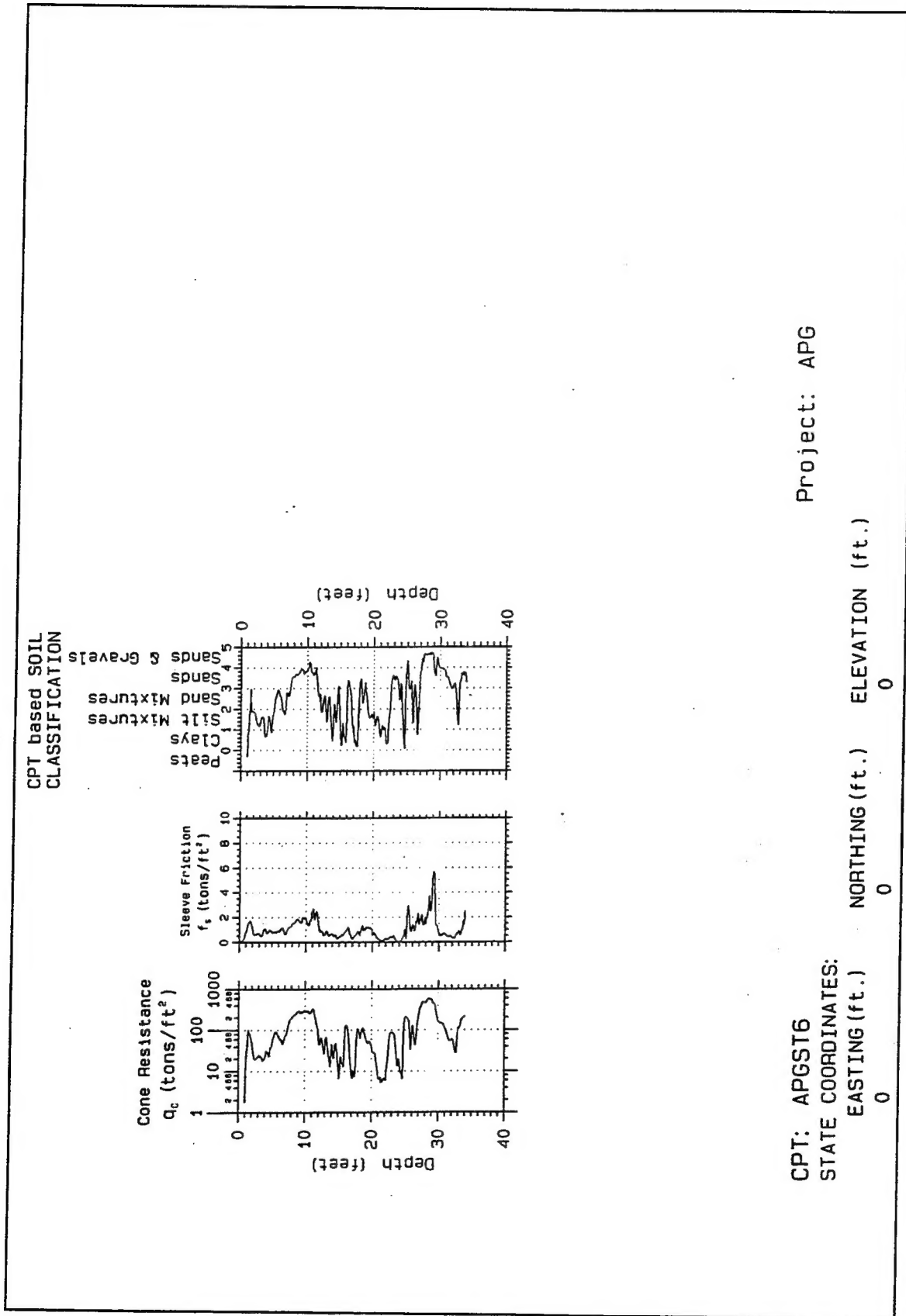


Figure A6. Stratigraphy CPT APGST 6 at Building 525, Aberdeen Proving Ground

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**12a. DISTRIBUTION / AVAILABILITY STATEMENT**

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**12b. DISTRIBUTION CODE****13. ABSTRACT (Maximum 200 words)**

Site characterization for subsurface contaminants is time-consuming and costly. The Tri-Service Site Characterization and Analysis Penetrometer System (SCAPS) has been developed to reduce the time and cost required for site characterization. Sensors have been developed for a variety of contaminants of concern to the Department of Defense.

The Hydrosparge Volatile Organic Compound (VOC) groundwater sensing system has been developed and was demonstrated at Aberdeen Proving Ground (APG), MD, in August 1995. The Hydrosparge is capable of accessing groundwater, sparging VOC contaminants in situ, and analyzing the contaminant concentrations using a field portable ion trap mass spectrometer. During the 7-day demonstration at Building 525, APB, a total of 29 SCAPS penetrations were performed: 6 stratigraphic penetrations and 23 Hydrosparge penetrations.

The results obtained with the SCAPS in situ technique were verified by collecting groundwater samples and analysis of the verification samples by U.S. Environmental Protection Agency (EPA) Method 8260. Results of verification sample analyses indicated a strong linear relationship with EPA Methods. The SCAPS Hydrosparge deployment at Building 525, APG, demonstrated the rapid site characterization capabilities of the SCAPS VOC sensor.

**14. SUBJECT TERMS**Groundwater contamination      Site characterization  
Penetrometer                      VOC  
SCAPS                                Volatile organic compounds**15. NUMBER OF PAGES**

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